
SPORT

The Scintillation Prediction Observations Research Task

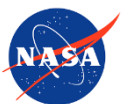
James F. Spann, NASA/MSFC

Presentation at FAPESP, São Paulo, SP, 2015-12-17



Outline

- Science
- Mission – instruments, spacecraft, mission
- Team Responsibilities
- Backup



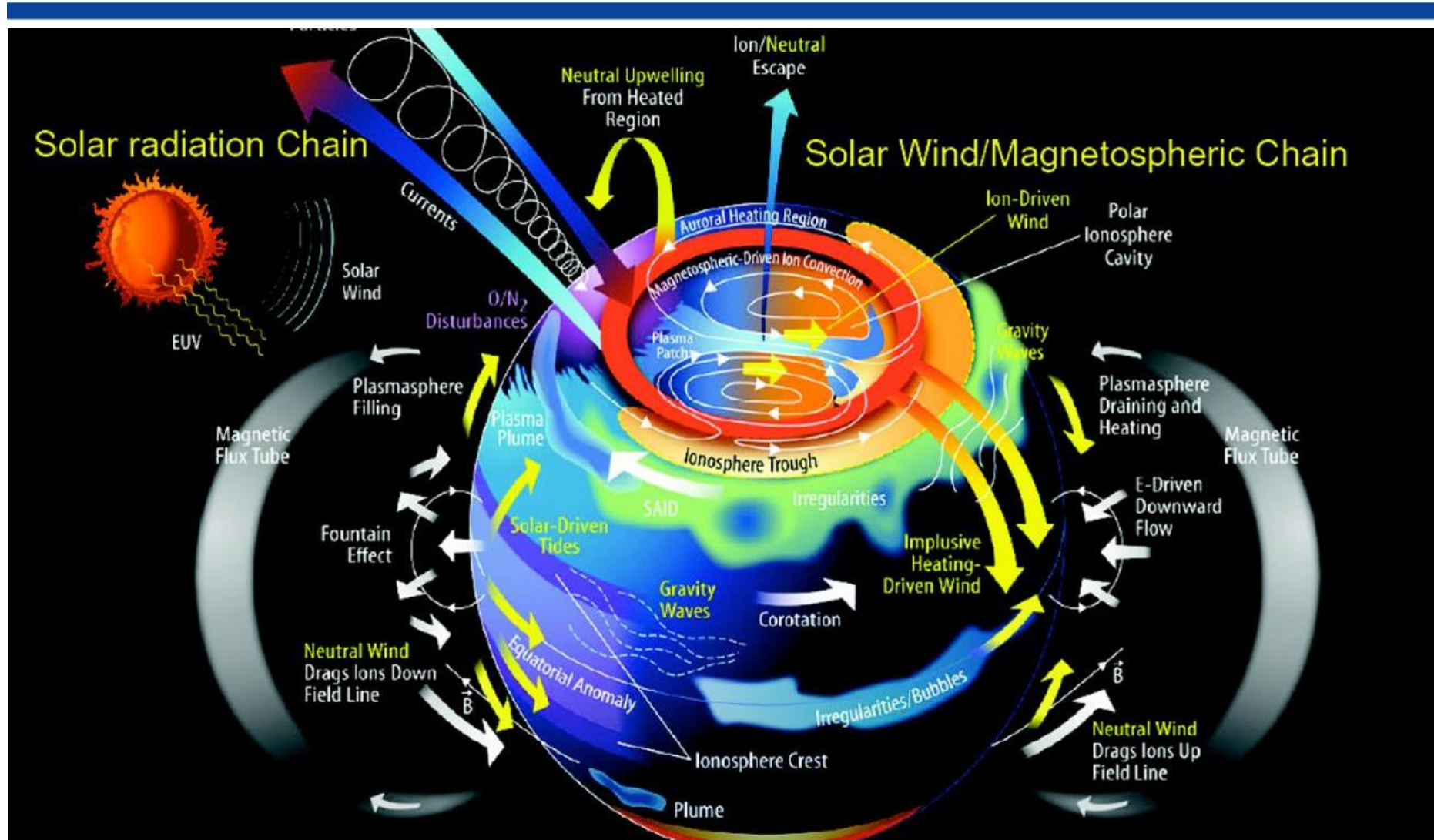
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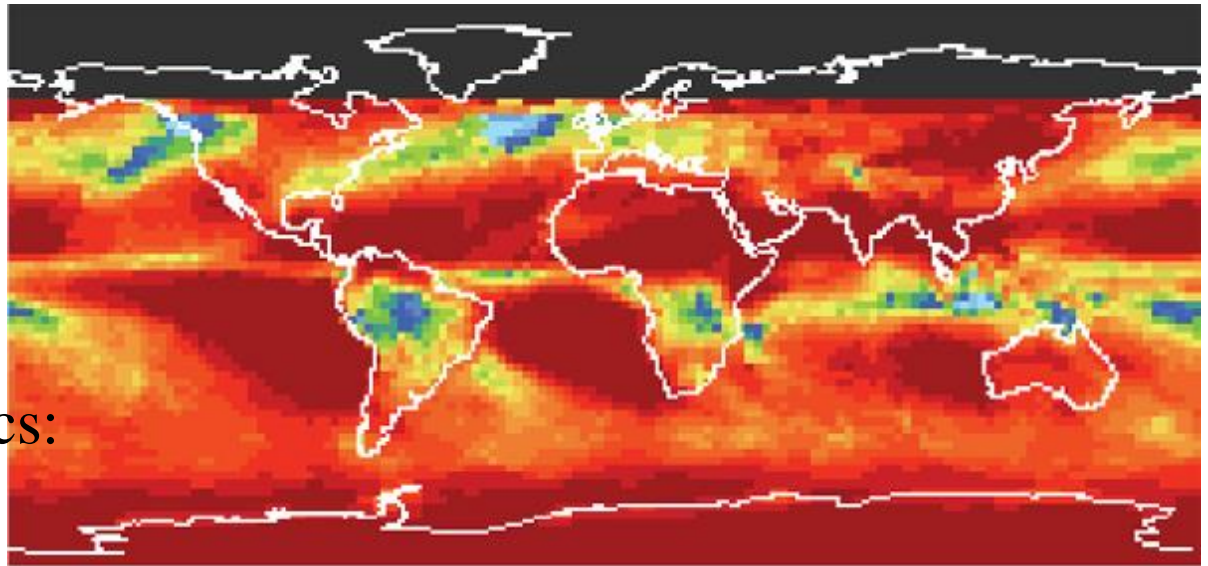
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Ionosphere-Thermosphere-Mesosphere



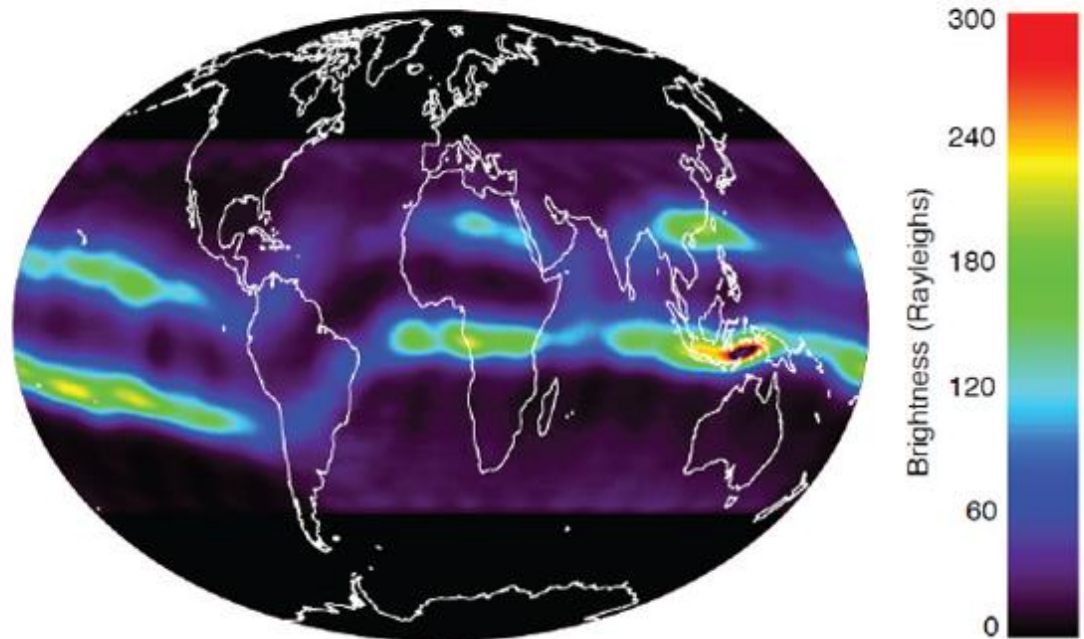
Daytime Convective Clouds Coverage



The US National Academy of Science published a Decadal Survey entitled:

Solar and Space Physics:
A Science for a
Technological Society
(2013)

Chapter 2: Solar and
Space Physics: Recent
Discoveries, Future
Frontiers

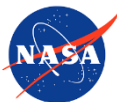


Average Ionospheric Equatorial Densities

Top Challenges for the Atmosphere-Ionosphere-Magnetosphere Interactions



- Understand how the ionosphere-thermosphere system responds to, and regulates, magnetospheric forcing over global, regional, and local scales.
- Understand the plasma-neutral coupling processes that give rise to local, regional, and global-scale structures and dynamics in the AIM system.
- Understand how forcing from the lower atmosphere via tidal, planetary, and gravity waves influences the ionosphere and thermosphere.



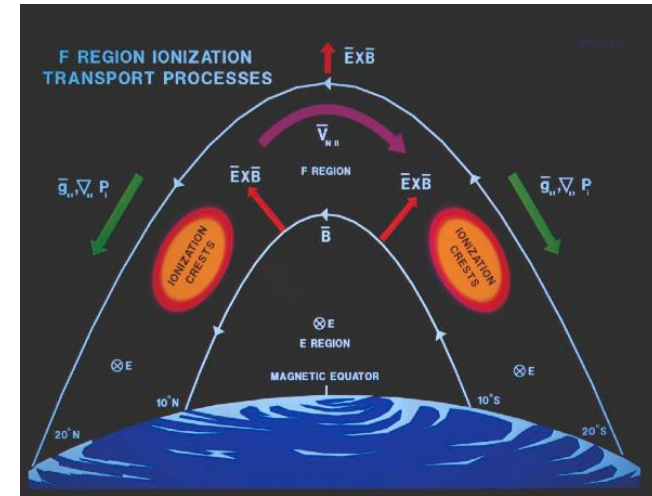
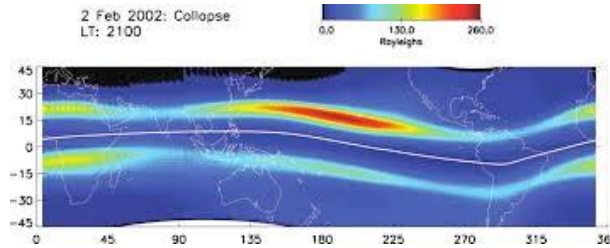
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Science

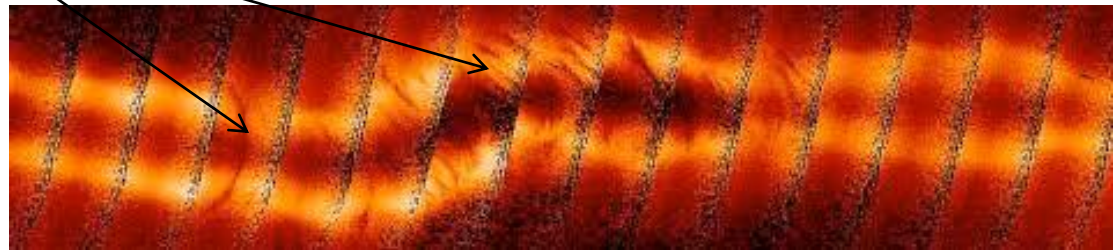
- The equatorial ionization anomalies



- Plasma Bubbles

GUVI (Same Local Time, Different Longitudes)

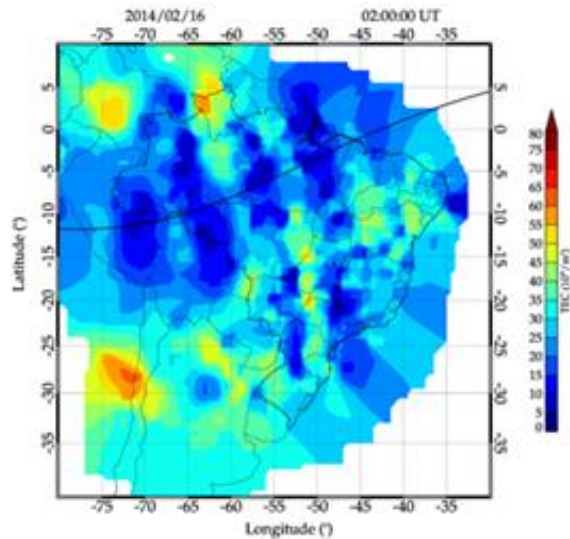
Why do bubbles sometimes form and sometimes not?



Kil, Hyosub, et al. "Coincident equatorial bubble detection by TIMED/GUVI and ROCSAT-1." Geophysical research letters 31.3 (2004).



Ground Observations of Total Electron Content

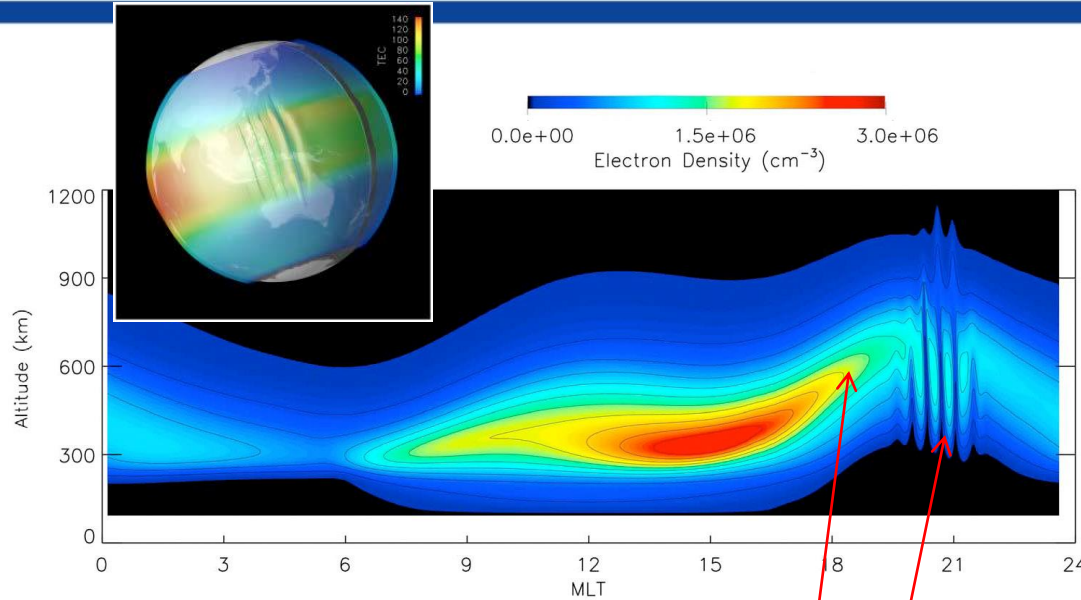


TEC map over South America showing plasma depletion regions (left) and associated regions of scintillation near the anomaly peak. Source: EMBRACE data center.



Plasma Bubble Modeling

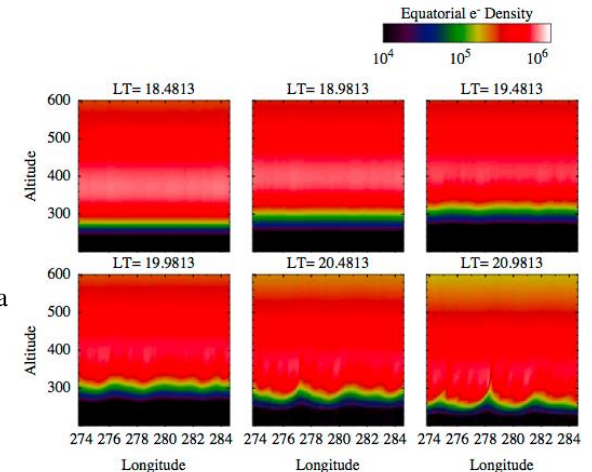
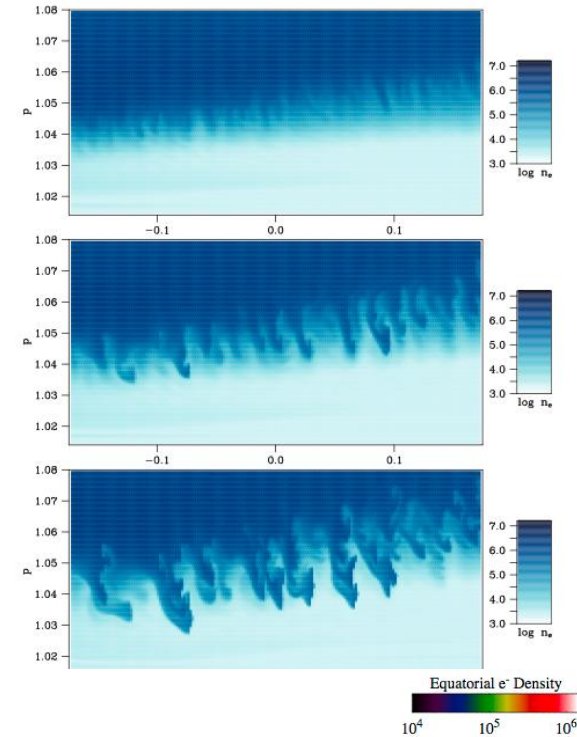
About 1.5 Hours to form a bubble



What is the state of the ionosphere here?

That leads to bubbles here ?

When bottom side seeding perturbations seem to always be present



Retterer, J. M., and P. Roddy. "Faith in a seed: on the origins of equatorial plasma bubbles." *Annales Geophysicae*. Vol. 32. No. 5. Copernicus GmbH, 2014.

SPORT Science Goals

- What is the state of the ionosphere that gives rise to the growth of plasma irregularities that extend into and above the F-peak?
- How do plasma irregularities evolve to impact the appearance of radio scintillation at different frequencies?



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SPORT Science Traceability

Table 1. Science Objectives to Measurement Requirements Traceability

The Scintillation Prediction Observation Research Task (SPORT)	Instrumentation	Spacecraft
Observational Approach	Science Measurement Requirements	Space Systems Requirements
1) What is the state of the ionosphere that gives rise to the growth of plasma irregularities that extend into and above the F-peak?		
<p>Observations in the 1700 to 1000 LT Sector over 30° to 30° latitude</p> <p>Height profiles of the plasma density to specify the magnitude and height of the F-peak density in the EA</p> <p>Vertical ion drifts at or below the F-peak in the EA</p>	<p>Plasma Density Profile</p> <ol style="list-style-type: none"> 1) 40 to 50 km alt 2) 10^4 to 10^7 p/cm³ range 3) 20% p/cm³ accuracy 4) 1000 km long track sampling <p>Ion Drifts (Earth Reference Frame)</p> <ol style="list-style-type: none"> 1) 800 m/s range 2) 20 m/s precision & accuracy 3) 10 km long track sampling 	<p>GPS Occultation</p> <p>Observe GPS satellite occultation along and to the sides of the orbit plane to obtain line of site TEC</p> <p>Ion Velocity Meter</p> <p>Observe vertical ion drifts by angle of arrival of heavy ions at detector</p> <p>Satellite Orbit</p> <ol style="list-style-type: none"> 1) 1 year mission life 2) 40° to 55° inclination 3) 50 to 50 km altitude 4) 10 km eccentricity <p>Spacecraft</p> <ol style="list-style-type: none"> 1) 15° Ram Pointing Lo 2) 1 km position knowledge 3) 10 ms timing
2) How do plasma irregularities evolve to impact the appearance of radio scintillation at different frequencies?		
<p>Observations in the 200 to 2000 LT Sector over 30° to 30° latitude</p> <p>Observations of irregularities in electron density and E-field power spectral density in slope from 200 km to 2000 km</p>	<p>E-Field (Earth Reference Frame)</p> <ol style="list-style-type: none"> 1) 45 mV/m range 2) 1.1 mV/m precision & accuracy 3) 1 km long track sampling 4) 10 km to 2000 km long track waves <p>Plasma Density</p> <ol style="list-style-type: none"> 1) 10^3 to 10^7 p/cm³ range 2) 10^3 p/cm³ precision & accuracy 3) 1 km long track sampling 4) 10 km to 2000 km long track waves <p>B-field</p> <ol style="list-style-type: none"> 1) 56,000 nT range 2) 100 nT precision and accuracy 3) 1 km long track sampling 	<p>E-Field Double Probe</p> <p>Observe probe floating potential for AC fields from irregularity</p> <p>GPS Occultation</p> <p>S4 scintillation index</p> <p>Langmuir/Impedance</p> <p>Observe DC and AC probe response for relative and absolute electron density and observed irregularities</p> <p>Three Axis Magnetometer</p> <p>Support VxB computation for ion velocity and E-field measurements</p> <p>Spacecraft Mechanisms</p> <ol style="list-style-type: none"> 1) 0.6 m tip-to-tip booms <p>Attitude Post Flight Knowledge</p> <ol style="list-style-type: none"> 1) 0.02° 1σ uncertainty



Instrument Measurement Mapping

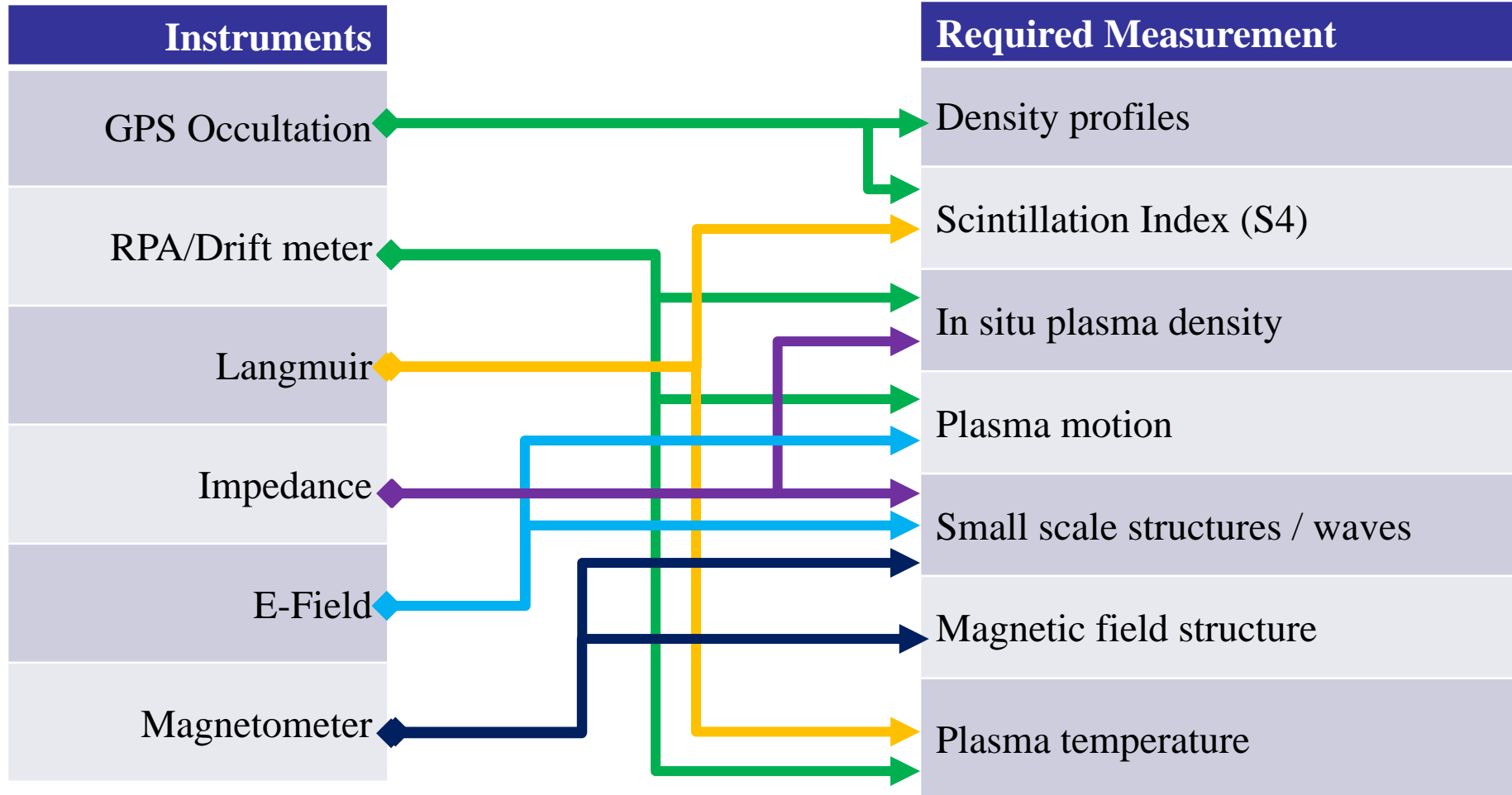
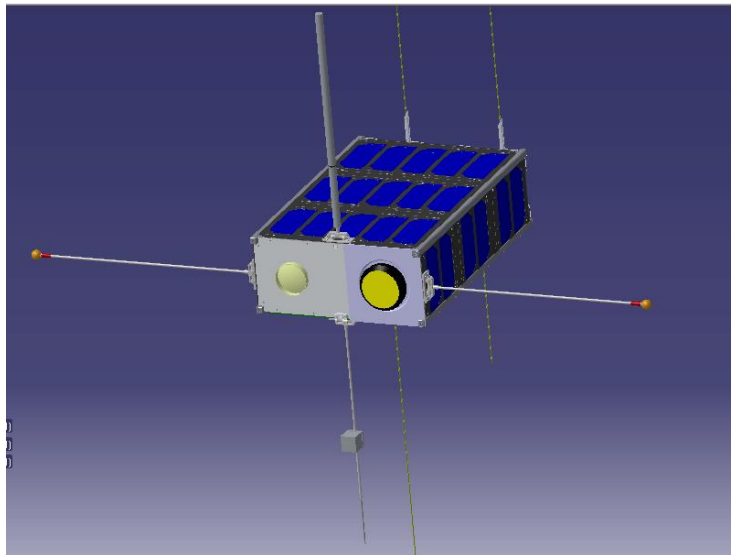
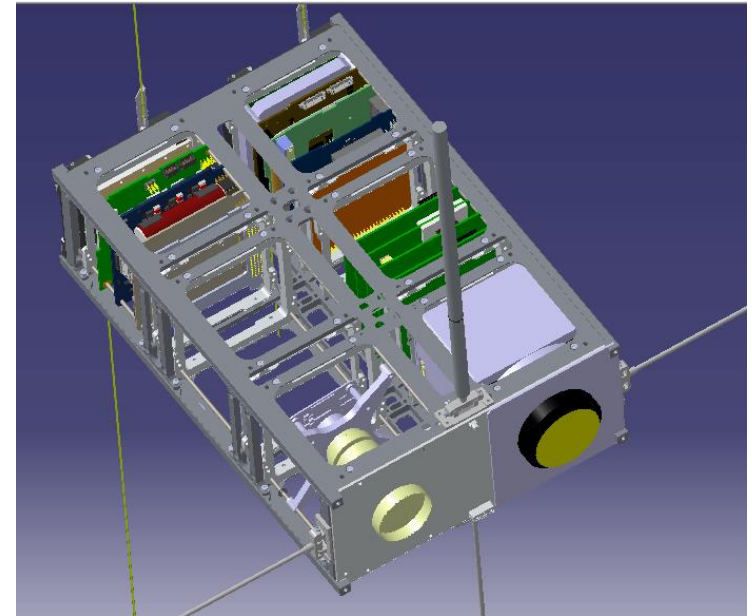
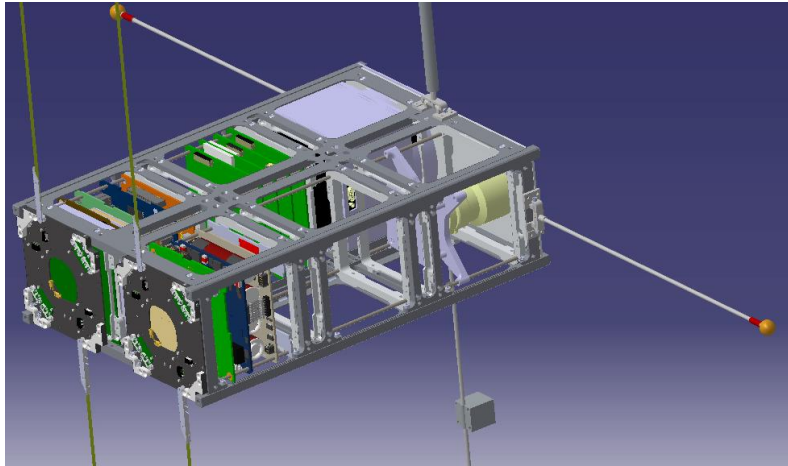


Table 1. Expected Instrument Performance and Requirements

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SPORT Spacecraft

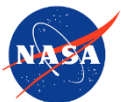


SPORT CAD
drawings: ITA
(Lidia Sato)



SPORT Mission

- ISS-like orbit is different from other missions such as COSMIC and C/NOFS
- Provides near conjugacy observations across equatorial anomaly
- Science mission on a CubeSat platform



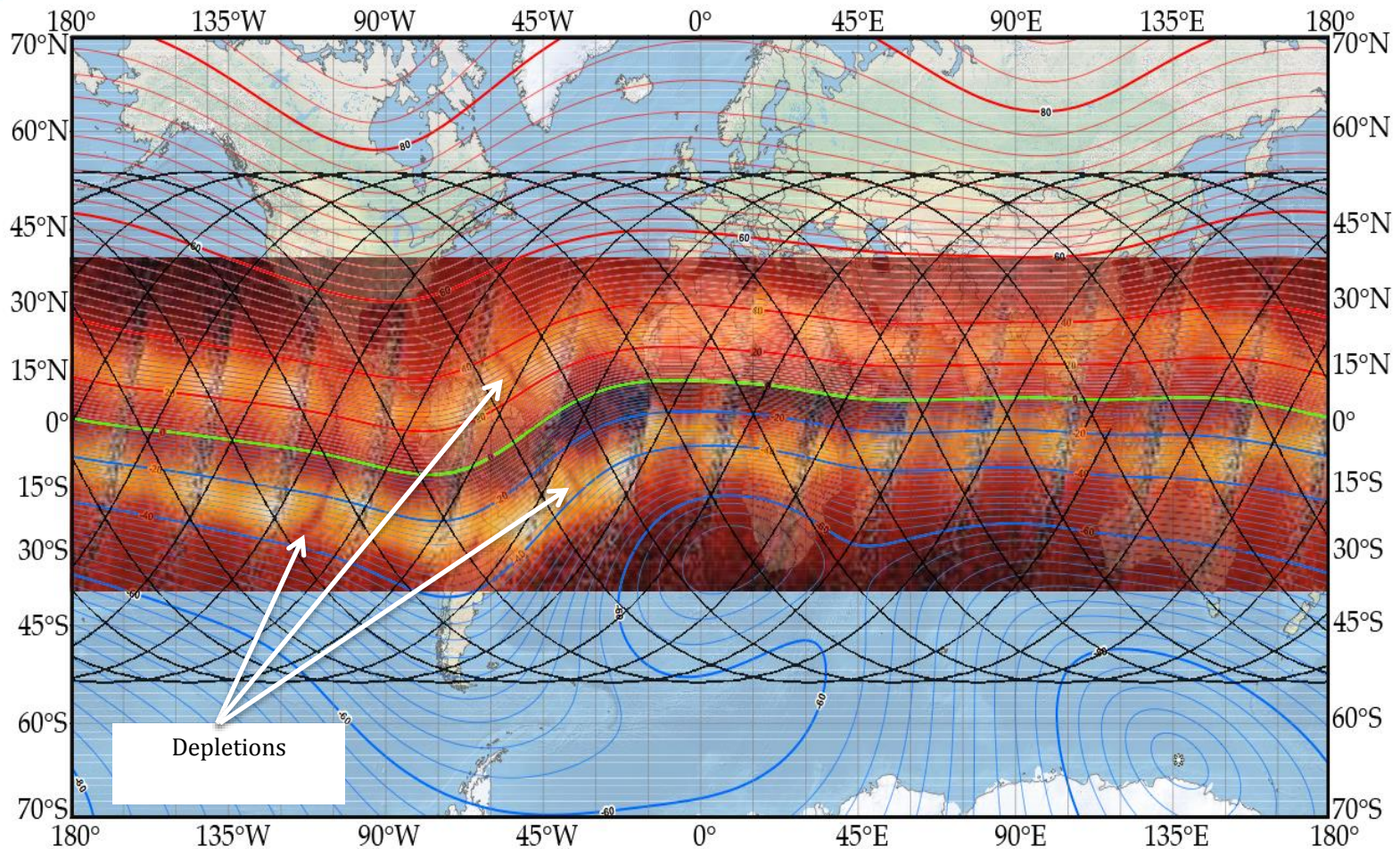
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SPORT Orbit



UV Airglow images from TIMED clearly show the equatorial anomaly with embedded depletions that have penetrated the F peak. Green, red, and blue traces show the magnetic equator and positive and negative dip angles. SPORT ground tracks are superimposed in black.



SPORT Team and Functions

- **MSFC**

- PI, PM, Science Co-I, single interface to Brasil, Engineering oversight of instruments and observatory I&T, Launch and DoD coordination

- **Instruments** – Each instrument has a US and Brasil science counterpart

- Utah State: Deputy PI, Langmuir and Impedance Probe, Star Camera
- Aerospace Corp – Co-I, GPS Occultation
- University of Texas at Dallas – Co-I, Drift Meter
- GSFC – Co-I, Magnetometer, Data Archival at SPDF

- **UAH**

- System Engineering Support

- **ITA**

- Spacecraft, Observatory I&T

- **INPE**

- Ground observation network, Mission Ops, Data management and distribution/archive



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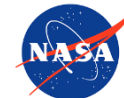
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Overall Schedule

Date	Activity/Milestone
March 2016	Mission Initiation and Requirements Definition Review
May 2016 - September 2017	Spacecraft Development
February/May 2017	Instrument/Spacecraft Design Reviews
May 2017	Instrument Delivery
June – September 2017	I&T
February 2018	Mission Readiness Review
May 2018	Launch Readiness Date
Summer 2018	Data Analysis Workshop
Summer 2018 – Spring 2019	Analysis of data, Publication of results





Name	Role	Institution	Effort
Dr. James Spann*	Principle Investigator	MSFC	0.17
Mr. Steve Pavelitz	Instrument Manager + NASA PM	MSFC	1.00
Mr. Erick Ordoñez	MSFC LSE	MSFC	0.50
Dr. Charles Swenson*	Deputy PI/Co-I Langmuir/Impedance	USU	0.12
Dr. Joaquim E. R. Costa*	INPE Instrument Manager	INPE	0.20C
Dr. Polinaya Muralikrishana*	Co-I Langmuir/Impedance Scientist	INPE	0.20C
Dr. Guan Le*	Co-I Magnetometer	GSFC	0.05C
Dr. Clezio Marcos Denardini*	Mission Data Scientist	INPE	0.20C
Dr. Rod Heelis*	Co-I Drift Meter	UTD	0.05/0.05C
Dr. Mangalathayil Ali Abdu*	Co-I Drift Meter Scientist	DCTA/ITA	0.15C
Dr. Rebecca Bishop*	Co-I Radio Occultation	Aerospace	0.83
Dr. Hisao Takahashi*	Co-I Radio Occultation Scientist	INPE	0.20C
Dr. David Sibeck*	Collaborator Science	GSFC	0.05C
Dr. Efythia Zesta*	Collaborator Science	GSFC	0.05C
Dr. Linda Krause*	Co-I Science	MSFC	0.15
Dr. Jim Clemmons*	Collaborator Science	Aerospace	0.05C
Mr. Joe Casas	Mission Manager	MSFC	0.10
Dr. Luis Loures	Project Manager & DCTA/ITA Lead POC	DCTA/ITA	0.50C
Dr. Elói Fonseca	Systems Engineer	DCTA/ITA	0.50C
Dr. Bryan Mesmer	UAH Systems Engineering support	UAH	0.09
Dr. Otávio Durão	INPE Lead POC	INPE	0.40C
Dr. José Sergio de Almeida	I&T Lead	INPE	0.20C
Dr. Maria de Fátima Mattiello	GSE and Ops Lead	INPE	0.30C
Mr. Marcelo Essado	Ground Software Lead	INPE	0.30C
Mr. Juan Hurtado	Collaborator Mission	SOUTHCOM	0.05 C
Dr. Steve Spehn	Collaborator Mission	EUCOM	0.05 C
Dr. Pierre Mattei	Collaborator Mission Partnership	DCTA/ITA	0.15 C
Dr. Maurício Ferreira	Control Center Operations Lead	INPE	0.20C



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Organization

